Ecosystem Productivity and Energy Flow of Three-Hardwood Forest

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ABSTRACT: The main characteristics of energy environment, energy products, primary productivity and basic process of energy flow for three-hardwood forest(*Juglans mandshurica, Fraxinus mandshurica,* and *Phellodendron amurense*) were studied. The research was mainly based on the theory and method of community energetics, dealing with fixed position, quantitative test and experimental analysis. The time-space dynamics of sun-radiation in three-hardwood forest were measured and the energy compartment model was set up. his research work provided a scientific basis for the exploitation, utilization and management of three-hardwood forest.

Key words: Productivity, Energy flow, Three-hardwood forest, Compartment model, Energy environment

INTRODUCTION

The research work was carried out in the Daqing Centre of Chaihe Forest Bureau, Northeast China. There, the three-hardwood forest distributed a little broadly. The existence, movement, development and dynamics of forest community depend on the energy, energy flow and substance circulation, and bio-production process. Energy flow is the basic function to the forest. The study on the energy flow and community productivity is the main tend of ecological work. Energy flow is the process of sun-radiation energy which is absorbed, fixed, transformed and consumed by forest community. It influences on the structure, succession and productivity of community. In order to develop the productivity, promote the material cycle, improve the utilizing rate of energy flow and provide the basic information for the theoretical study. The research on ecosystem productivity and energy flow is becoming more necessary to manage three hardwood forest.

METHODS

Sun-radiation intensity was determined at 17 m high observing tower in the field sampling land. From forest canopy to ground, in line with canopy structure and layer feature, 4-layer observing platforms was set up. Sun- radiation energy was measured by DFY-2 type sky-radiation meter and DFY-1 radiation galvanometer. Photosynthesis available radiation was measured by GTJ-1 available radiation meter. Illuminance of different layer in the community was determined by QZ-CZ type micro-illuminometer. Leaf area was measured by CY-400 type light-electron area meter. Bio-productivity was measured by harvest method. Caloricity was determined by DAOJIN CA-3 type oxygen-bomb caloricity.

RESULTS AND ANALYSES

Energy Environmental Characteristics of the Three-Hardwood Forest Energy environmental characteristics of community was composed of various energy forms which composed and controlled by sun-radiation in living space of the plant-community.

Sun-radiation energy reaching to the forest canopy In the growing season from May to September, sun-radiation intensity was 5,453,787 KJ/m^2. Sun-radiation reaching to the three-hardwood forest was 2,525,926.66 KJ/m^2, with 54% decline.

Time dynamics of sun-radiation energy distribution Day-dynamics of direct radiation is single-peak curve. Its peak value occurrs at about 12 o'clock. Season's dynamics changes greatly, and its peak value was 44725.3 KJ/m^2 ·Month, appearing at September. May's value was secondary and July's value was the lowest. The dynamics of scattering-radiation is similar to the direct-radiation, and its season's dynamics presents wave type. Value in May is relatively high. Peak value in July is the highest and the lowest value appears in September.

Dynamics of photosynthesis available radiation(PAR) in three-hardwood forest(Fig. 1 and 2)

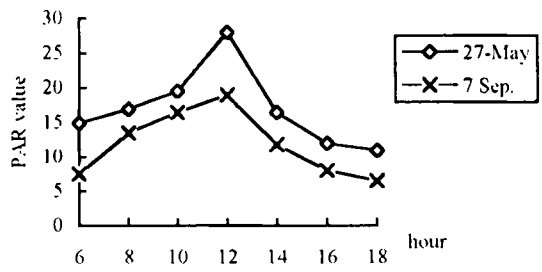

Fig. 1. Day dynamics of PAR in three-hardwood forest
PAR photosynthesis available radiation(KJ/m^2·h)

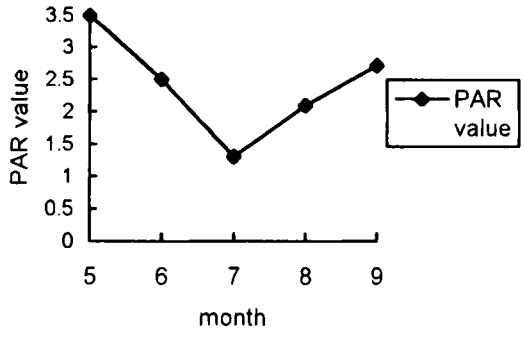

Fig. 2. Season's dynamics of total PAR value in three-hardwood forest

PAR=photosynthesis available radiation(10^6KJ/m^2·month)

Energy Production Status Energy production of three-hardwood forest is the primary productivity of various energy-contained products which formed by net photosynthesis of community. The energy value of plant energy-contained products is generally indicated by caloricity.

Distribution and changes of energy content in three-hardwood forest

Arborous layer: Average caloricity order is: *Juglans mandshurica* > *Tilia amurensis* > *Ulmus propinqua*>*Fraxinus mandshurica* > *Phellodendron amurense* > *Acer mono*.

Brushwood layer: Caloricity of roots(18.396 KJ/g) is greater than that of stems (16.866 KJ/g). The order is root > leaf > stem and branch.

Herbaceous layer: Average energy content above ground(16.642 KJ/g) is lower than that underground (19.052 KJ/g).

Energy content distribution: The order of energy content in three hardwood forest is arborous layer > brushwood layer > herbaceous layer (Table.1).

Table 1. The Energy content distribution in three hardwood forest (KJ/g)

	Arborous layer	Brushwood layer	Herbaceous layer	Litter
Upper ground	19.283	17.359	16.642	17.907
Under ground	20.022	18.396	19.052	
Average	19.653	17.878	17.847	

Distributon of biomass energy in three hardwood forest

(1) Distribution of biomass energy in arborous layer and different organs: The order of biomass energy is tree trunk>root>branch>bark>leaf>innovation(Table.2).

Tab.2. Biomass(T/hm^2) and biomass energy(10^6 KJ/hm^2) of different organs in arborous layer

		Tree trunk	Trunk bark	New Branch	Branch	Leaf	Root	Total	Percentage
Ph. amurense	Biomass	11.847	0.986	0.050	2.588	1.131	2.862	19.464	23.20
	Biomass energy	213.319	17.496	1.009	50.119	22.196	51.897	355.856	22.41
F. mandshurica	Biomass	6.016	0.842	0.083	2.050	0.658	1.734	11.365	13.55
	Biomass energy	112.409	15.532	1.555	40.078	12.174	34.611	216.400	13.63
J. mandshurica	Biomass	15.561	3.824	0.088	4.121	1.663	18.585	43.842	52.25
	Biomass energy	303.564	74.262	1.752	77.500	33.436	347.725	838.239	52.79
Others	Biomass	5.323	0.670	0.034	1.475	0.291	1.440	9.233	11.00
	Biomass energy	102.542	12.144	0.686	29.060	5.554	27.448	177.434	11.17
	Biomass	38.747	6.304	0.255	10.234	3.743	24.621	83.904	100
	Percentage	46.18	7.51	0.30	12.20	4.46	29.34	100	
Total	Biomass energy	731.654	119.425	5.000	196.757	73.360	461.731	1587.929	100
	Percentage	46.08	7.52	0.32	12.39	4.62	29.08	100	

(2) Biomass energy in brushwood layer mainly distributed in the roots, trunk, and branch, few in the leaves(Table 3).

Table 3. Distribution characteristics of biomass energy in brushwood layer (T/hm^2) (10^6 KJ/hm^2)

	Trunk and Branch	Leaf	Root	Total
Biomass	5.8	1.01	5.41	12.23
Percentage	47.51	8.26	44.24	100
Biomass energy	97.790	18.282	99.396	215.669
Percentage	45.44	8.48	46.09	100

(3) Biomass energy under ground is greater than that upper ground in herbaceous layer (Tab.4)

Table 4. Distribution feature of biomass energy in herb layer (KJ/m^2) (10^3 KJ/m^2)

	Upper ground	Under ground	Total
Biomass	0.065	0.072	0.137
Percentage	47.45	52.55	100
Biomass energy	1.082	1.372	2.454
Percentage	44.09	55.91	100

(4) The Biomass energy in three hardwood forest mainly exists in arborous layer, brushwood layer is secondary and herb layer is the lowest.(Tab.5)

Net primary productivity(NPP) and distribution in three hardwood forests

(1) Arborous layer: The order of NPP in arborous

layer is leaf>trunk> root > branch > bark(Table 6).

Table 5. Distribution of biomass energy in three hardwood forest (T/hm^2) (10^6 KJ/hm^2)

	Arborous layer	Brushwood layer	Herb layer	Litter	Total
Biomass	83.904	12.230	1.37	2.417	99.930
Percentage	83.96	12.24	1.40	2.42	100
Biomass energy	1648.965	218.648	24.450	43.281	1935.344
Percentage	85.20	11.30	1.27	2.24	100

Table 6. Distribution of net primary productivity in arborous layer(10^6 KJ/hm^2)

Organs	Trunk	Trunk bark	Branch	Leaf	Root	Total
NPP	20.532	3.632	10.878	72.088	17.967	125.10
Percentage	16.41	2.69	8.70	57.63	14.36	100

(2) Brushwood layer: Net primary productivity of root is slightly greater than trunk branch and leaf (Table7).

(3) Herb layer: Net primary productivity of herb layer is about 10.817× 10^6KJ/hm^2 · a

(4) Net primary productivity of three hardwood forests is manly distributed in arborous layer, taking 64%; brushwood layer is secondary, taking above 30% (Table 8).

Table 7. Distribution of NPP in brushwood layer (10^6 KJ/ha · a)

Organs	Trunk and Branch	Leaf	Root	Total
NPP	19.598	18.031	21.891	59.520
Percentage	32.93	30.29	36.78	100

Table 8. Distribution of NPP in three hardwood forests (10^6 KJ/hm^2 · a)

Layer	Arborous layer	Brushwood layer	Herb layer	Total
NPP	125.088	59.520	10.817	195.425
Percentage	64.01	30.46	5.54	100

Analysis of Energy Flow Process in Three Hardwood Forests Energy flow of forest is a bio-physical-chemical process of sun-radiation energy which was absorbed, located, transformed and consumed by forest community. The energy flow process in three hardwood forests can be shown by compartment model as Fig. 3.

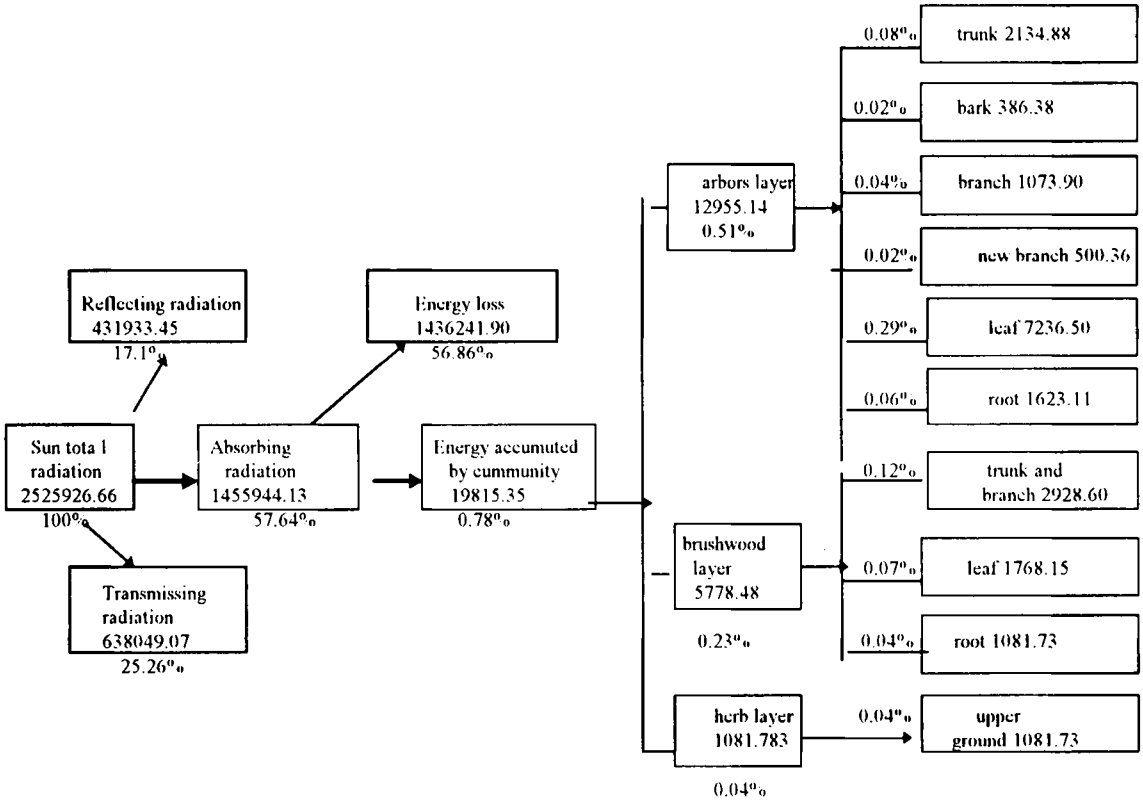

Fig. 3. Compartment model of energy flow process in three-hardwood forest (Unit: KJ/m^2)

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